Acknowledgements:

I thank Thiru S.S. Jawahar, IAS, Commissioner of Museums, who has evinced keen interest amongst his manifold duties, in enriching and developing the Geology gallery and also for his extensive guidance in bringing out this handbook. I profusely thank him for his guidance and leadership. I am also grateful to Thiru. S. Annadurai, Technical Assistant, Thiru. Panneer Selvam, Assistant Photographer and Tmt. S.Thara, Steno-typist for their valuable assistance in this project.

R.D. Thulasi Brinda

GEOLOGICAL HISTORY OF INDIA

The geological history of India started with the geological evolution of rest of the Earth i.e. 4.57 (billion years ago). India has a diverse geology. Different regions in India contain rocks of many types belonging to different geological periods. Some of the rocks are badly deformed and transmuted while others are recently deposited alluvium that is yet to undergo digenesis. Mineral deposits of great variety are found in the subcontinent in huge quantities. Even the fossil records are impressive in which stromatolites, invertebrates, vertebrates and plant fossils are included. India's geographical land area can be classified as Deccan Trap, Gondwana and Vindhyan.

Firstly, the Deccan Trap covers almost all of Maharashtra, a part of Gujarat, Karnataka, Madhya Pradesh and marginally Andhra Pradesh. It is believed that the Deccan Trap was formed as result of sub-aerial volcanic activity associated with the continental deviation in this part of the Earth during the Mesozoic era. That is why the rocks found in this region are generally igneous type.

During its journey northward after breaking off from the rest of Gondwana, the Indian Plate passed over a geologic hotspot, the Reunion hotspot, which caused extensive melting underneath the Indian craton. The melting broke through the surface of the craton in a massive flood basalt event, creating what is known as the Deccan Traps. It is also thought that the Reunion hotspot caused the separation of Madagascar and India.

The Gondwana and Vindhyan include parts of Madhya Pradesh, Chhattisgarh, Orissa, Bihar, West Bengal, Andhra Pradesh, Maharashtra, Jammu and Kashmir, Punjab, Himachal Pradesh, Rajasthan and Uttarkhand.

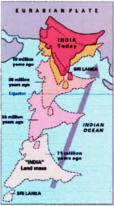
The Gondwana Supergroup forms a unique sequence of fluviatile rocks deposited in Permo-Carboniferous time. Damodar and Sone river valley and Rajmahal hills in the eastern India are depository of the Gondwana rocks.

Plate Tectonics:

The Indian Craton was once a part of the Supercontinent of Pangea. At that time, it was attached to Madagascar and southern Africa on the south west coast, and Australia along the east coast 160Ma (ICS 2004) during the Jurassic Period, rifting caused Pangaea to break apart into two supercontinents namely, Gondwana (to the south) and Laurasia (to the north). The Indian craton remained attached to Gondwana, until the supercontinent began to drift apart about in the early Cretaceous, about 125 Ma (ICS 2004). The Indian Plate then drifted northward toward the Eurasian Plate, at a pace that was the fastest movement of any known plate. About 90 Ma (ICS 2004), the Indian plate separated from Madagascar. The Indian Plate began collided with the Eurasian Plate about 50 Ma (ICS 2004). This orogeny, which is continuing today, is related to closure of the Tethys ocean. The closure of this ocean which created the Alps in

Europe, and the Caucasus range in western Asia, created Himalaya Mountains and the Tibetan Plateau in South Asia. The current orogenic event is causing parts of the Asian continent to deform westward and eastward on either side of the orogeny. Concurrently with this collision, the Indian Plate sutured on to the adjacent Australian Plate, forming a new larger plate, the Indo-Australian Plate.

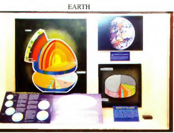
Tectonic Evolution :



Due to continental drift, the India Plate split from Madagascar and collided with the Eurasian Plate resulting in the formation of the Himalayas.

The earliest phase of tectonic evolution was marked by the cooling and solidification of the upper crust of the earth surface in the Archaean era (prior to 2.5 billion years) which is represented by the exposure of gneisses and granites especially on the Peninsula. These form the core of the Indian craton. The Aravalli Range is the remnant of an early Proterozoic orogen called the Aravalli-Delhi orogen that joined the two older segments that make up the Indian craton. It extends approximately 500 kilometres from its northern end to isolated hills and rocky ridges into Haryana, ending near Delhi.

EARTH



Minor igneous intrusions, deformation (folding and faulting) and subsequent metamorphism of the Aravalli Mountains represent the main phase of orogenesis. The erosion of the mountains and further deformation of the sediments of the Dharwaian group (Bijawars) marks the second phase. The volcanic activities and intrusions, associated with this second phase are recorded in the composition of these sediments.

Early to Late Proterozoic calcareous and arenaceous deposits, which correspond to humid and semi-arid climatic regimes, were deposited in the Cuddapah and Vindhyan basins. These basins which border or lie within the existing crystalline basement, were uplifted during the Cambrian (500 Ma (ICS 2004)). The sediments are generally undeformed and have in many places preserved their original horizontal stratification. The Vindhyans are believed to have been deposited between ~1700 and 650 Ma (ICS 2004).

Early Paleozoic rocks are found in the Himalayas and consist of southerly derived sediments eroded from the crystalline craton and deposited on the Indian platform.

In the Late Paleozoic, Permo-Carboniferous glaciations left extensive glacio-fluvial deposits across central India, in the new basins created by sag/normal faulting. These tillites and glacially derived sediments are designated as the Gondwanas series. The sediments are overlaid by rocks resulting from a Permian marine transgression (270 Ma (ICS 2004)).

The late Paleozoic coincided with the deformation and drift of the Gondwana supercontinent. To this drift, the uplift of the Vindhyan sediments and the deposition of northern peripheral sediments in the Himalayan Sea, can be attributed.

During the Jurassic, as Pangea hegan to rift apart, large grahens formed in central India filling Upper Jurassic and Lower Cretaceous sandstones and conglomerates.

By the Late Cretaceous India had separated from Australia and Africa and was moving northward towards Asia. At this time, prior to the Deccan eruptions, upliftment in southern India resulted in sedimentation in the adjacent nascent Indian Ocean. Exposures of these rocks occur along the south Indian coast at Pondicherry and in Tamil Nadu.

At the close of the Mesozoic one of the greatest volcanic eruptions in earth's history occurred, the Deccan lava flows. Covering more than 500,000 sq.kms (193,051 sq mi) area, these mark the final break from Gondwana.

In the early Tertiary, the first phase of the Himalayan orogeny, the Karakoram phase occurred. The Himalayan orogeny has continued to the present day.

HISTORY OF THE GEOLOGY GALLERY

The history of the Geology Section in the Chennai Museum is indeed quite interesting, in as much as the museum itself was started as a practical Geology Museum with 1100 Geological Collections in 1851 CE during the period of British East India Company. In 1828 CE, the Madras Literacy Society, a branch of the Asiatic Society of London, desired to have a Museum of Economic Geology at Madras and began collecting geological specimens. But lack of funds and space for a Museum, the Society addressed the then Madras Government to take the initiative in the formation of the Museum.

In 1843 CE, Major General W. Cullen suggested to the Government that starting a local Museum will help those interested in minerals development, encourage agriculture operators and lead to improvement of processes. On the basis of the letters of General Cullen and the Secretary, Madras Literary Society, the Court of Directors of the East India Company agreed, in 1846 AD, to the formation of Central Museum in Madras.

In 1850 CE, Assistant Surgeon, Edward Green Balfour, Medical Officer of the Governor's Bodyguard and Assay Master, offered his services as Officer-in-charge of the proposed Museum and his offer was accepted in 1851 CE. The Central Museum thus formed in the upper storey of the College of Fort. St. George with 1100 geological collections. Due to overcrowding of the rooms with the heavy geological specimens and more so owing to damage to the upper storey of the college by the weight of the objects and show cases, the museum was shifted to the Pantheon, in 1854 CE, which was then occupied by the *Cutchery* of the Collector of Madras.

With a humble start as a Museum of Practical Geology, its scope was later expanded to cover all the allied fields such as Archaeology, Anthropology, Botany, Zoology, Arts and Children's section, Numismatics etc to become a multi-purpose, public museum. Since then, the geological galleries have been considerably improved, reorganized and modernised, based on the changing needs of the time and the interest showed by the visitors.

GEOLOGY GALLERY

The Geological gallery is accommodated in the Main Building, near the Zoology Gallery of the Government Museum, Chennai. The geological objects are arranged in the Ground floor and the mezzanine floor.

The objects are classified and displayed under various groups such as the General geology, petrology, mineralogy, paleontology, climatology, environmental geology, planetary geology and economic geology.

The Geological gallery is a veritable treasure house of Indian minerals and has been rearranged so as to present to the visitors a fairly complete picture of stratigraphy and the range and variety of mineral wealth of India. The rocks and minerals are arranged in two different ways one with the object of showing their places in systematic studies and classification, and the other with the object of bringing out their importance in practical and industrial application. The practical and industrial applications of the rocks and minerals constitute the economic geology, to which a large space in the geology galleries has been dedicated. The practical application of rocks are mainly for building and constructional works. A good many stones used for structural construction are on display. Among them, the special ones are the stones used in the construction of the Mysore Maharaja's palace, the marble used in the sculpture of the Fort Church, Madras. The group of precious and semi-precious stones, cut and uncut, is one of the most attractive groups in the geology galleries.

The lignite industry of Neyveli is comprehensively represented. The exhibits consist not only of lignite samples and briquettes, but also of a few other materials relating to some of the subsidiary industries.

The animal fossils, the giant ammonite, brontosaurus and rhino fossil are some of the important and exciting exhibits. The fossil fauna of the Cretaceous period prevalent in large quantity in the Ariyalur and Trichy districts are important for their variety and age.

GENERAL GEOLOGY GALLERY

The main displays in the General Geology gallery are the pictorial exhibits of the earth, solar system, universe, effects and the impacts of volcanoes and earthquakes, tsunami, pollution etc.

Geologic processes:

Geologic processes drive the rock cycle and create landforms, structures and fossils. They include erosion, deposition, fossilization, faulting, uplift, metamorphism, volcanism and many others with less familiar names.

Geologic hazards are powerful expressions of geologic processes. Landslides, volcanic eruptions, earthquakes and tsunamis, climate change, flooding and cosmic impacts are extreme examples of ordinary things. Understanding the underlying geologic processes and creating necessary awareness are golden keys for mitigating geologic hazards in the larger interest of humanity. Likewise, studying catastrophic hazards relating to Rocks has become necessary to handle Natural Disaster Management and mitigation of ill-effects.

Geologic hazards:

Tectonics and Earth History:

Tectonics is geologic activity on the largest scale. As geologists mapped the world's rocks, untangled the fossil record and studied geologic features and processes, they hegan to raise and answer questions about tectonics—the life cycle of mountain ranges and volcanic chains, motions of continents, the rise and fall of the ocean and the doings of Earth's rocky mantle and iron core. Plate-tectonic theory, which explains tectonics as the motions in Earth's outer broken skin, has revolutionized geology, enabling us to study everything on Earth in a unified framework.

EVOLUTION OF LIFE

The earth was formed about four and half a thousand millions years ago. At that time it was a hot ball. The conditions related to life appeared only three thousand million years ago, after the earth had cooled down. The first living forms evolved in the oceans and they were very tiny and microscopic.

The Paleozoic era, which began about 570 million years ago saw marine life thriving, invertebrates were especially widespread and very soon the first vertebrates appeared on earth.

An event of great importance took place about four hundred million years ago. The vertebrates had left their water environment and together with the amphibians took their first step on dry land. From the amphibians the reptiles evolved.

Mesozoic era is also referred to as the golden age of reptiles. Marine, land and arial reptiles were flourishing.

Dinosaurs which were the most successful, reptiles lived rather ruled the earth between 235 and 65 million years ago.

Birds and mammals have evolved from the reptiles. During the Eocene period Giant flightless birds such as Diatruma preyed on the primitive horses which gave rise to modern horses and rhinoceros.

The transition from reptile-mammal is not marked by a quantum jump in evolution. It occurred gradually with these reptiles slowly acquiring mammal characteristics; in the upper 'Triassic' the first true mammals bave appeared.

PETROLOGY

Petrology is one of the important branches of Geology which deals with the study of rocks. Generally a rock is an aggregate of various minerals. Earth's crust is made up of 3000 minerals. They are found in three kinds of rocks.

ROCKS

Rocks are solid mixtures of at least one mineral. While minerals have crystals and chemical formulas, rocks instead have textures and mineral compositions. On that basis, rocks are divided into three classes reflecting three environments: igneous rocks, sedimentary rocks and metamorphic rocks. Rocks are important as ores-economic sources of useful minerals.

Igneous Rocks

Igneous rocks are formed from the solidification of molten rock material. There are two basic types:

1) **Intrusive igneous rocks** such as diorite, gabbro, granite and pegmatite that solidify below Earth's surface.

2) **Extrusive Igneous rocks** such as andesite, basalt, obsidian, pumice, rhyolite and scoria that solidify on or above Earth's surface.

Pictures and brief descriptions of some common igneous rock types are given below.

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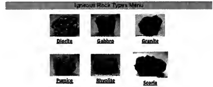


Basalt

Basalt is a fine-grained, dark-colored extrusive igneous rock composed mainly of plagioclase and pyroxene.

Diorite

Diorite is a coarse-grained, intrusive igneous rock that contains a mixture of feldspar, pyroxene, hornblende and sometimes quartz.

Gabbro

Gabbro is a coarse-grained, dark colored, intrusive igneous rock that contains feldspar, augite and sometimes olivine.

Granite

Granite is a coarse-grained, light coloured, intrusive igneous rock that contains mainly quartz and feldspar minerals.

Obsidian

Obsidian is a dark-coloured volcanic glass that forms from the very rapid cooling of molten rock material. It cools so rapidly that crystals do not form.

Pumice

Pumice is a light-coloured vesicular igneous rock. It forms through very rapid solidification of a melt. The vesicular texture is a result of gas trapped in the melt at the time of solidification.

Rhyolite

Rhyolite is a light-colored, fine-grained, extrusive igneous rock that typically contains quartz and feldspar minerals.

Scoria

Scoria is a dark-coloured, vesicular, extrusive igneous rock. The vesicles are a result of trapped gas within the melt at the time of solidification. It often forms as a frothy crust on the top of a lava flow or as material ejected from a volcanic vent and solidifying while airborne.

Syenite porphyry

It is a porphyritic rock with coarse laths of pink microcline embedded in a fine grained groundmass composed of finely granular pink microcline and dark green granular epidote. It differs from H2 in being sheared and the shear plane is characterized by quartz vein.

Hornblende syenite porphyry

It is a pale brownish grey, inequigranular, porphyritic rock. Coarse crystals of microcline perthite of brownish grey and vitreous lustre are embedded in a medium to fine-grained matrix essentially comprised of pale brownish grey feldspars and dark glistening grains of hornblende.

Diorite porphyry

It is a greenish grey porphyritic rock comprised of pale green, coarse plates of plagioclase embedded in a fine-grained groundmass of feldspars and hornblende, it is a dyke rock.

Dolerite

It is a fine grained, dense, dark grey rock comprised by of dark glistening granular pyroxenes and pale grey feldspars. It is a basic rock.

Sedimentary Rocks

Sedimentary rocks are formed by the accumulation of sediments. There are three basic types of sedimentary rocks:

1) **Clastic sedimentary rocks** such as breccia, conglomerate, sandstone and shale that are formed from mechanical weathering debris.

2) **Chemical sedimentary rocks** such as rock salt and some lime stones that form when dissolved materials precipitate from solution.

3) **Organic sedimentary rocks** such as coal and some limestones which form from the accumulation of plant or animal debris.

Pictures and brief descriptions of some common sedimentary rock types are given below.

Breccia

Breccia is a clastic sedimentary rock that is composed of large (over two millimeter diameter) angular fragments. The spaces between the large fragments can be filled with a matrix of smaller particles or a mineral cement which binds the rock together.

Conglomerate

Conglomerate is a clastic sedimentary rock that contains large (greater than two millimeters in diameter) rounded particles. The space between the pebbles is generally filled with smaller particles and/or a chemical cement that binds the rock together.

Limestone

Limestone is a rock that is composed primarily of calcium carbonate. It can form organically from the accumulation of shell, coral, algal and fecal debris. It can also form chemically from the precipitation of calcium carbonate from lake or ocean water. Limestone is used in many ways. Some of the most common uses are production of cement, crushed stone and acid neutralization.

Rock Salt

Rock Salt is a chemical sedimentary rock that forms from the evaporation of ocean or saline lake waters. It is also known by the mineral name "halite". It is rarely found at Earth's surface, except in areas of very arid climate. It is often mined for use in the chemical industry or for use as a winter highway treatment. Some halite is processed for use as a seasoning for food.

Sandstone

Sandstone is a clastic sedimentary rock made up mainly of sand-size (1/16 to 2 millimeter diameter) weathering debris. Environments where large amounts of sand can accumulate include beaches, deserts, flood plains and deltas.

Shale

Shale is a clastic sedimentary rock that is made up of clay-size (less then 1/256 millimeter in diameter) weathering debris. It typically breaks into thin flat pieces.

Laterite

It is a yellowish brown pisolitic rock which is essentially comprised of ferroginous quartz cemented by fine-grained clayey material much enricbed with powdery hematitic and limonitic material.

Banded Phyllite

It is a banded rock comprised of alternating layers of shaly and phyllitic materials. The phyllitic layers are narrow thin bands amidst the broader bands of shale. The phyllitic layers display micaceous sbeen. Whereas the shaly layers are pale yellowish grey in colour and possess a dull luster.

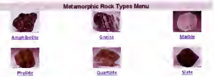
METAMORPHIC ROCKS

Metamorphic rocks have been modified by heat, pressure and chemical process usually while buried deep below Earth's surface. Exposure to these extreme conditions has altered the mineralogy, texture and chemical composition of the rocks. There are two basic types of metamorphic rocks:

1) **Foliated metamorphic rocks** such as gneiss, phyllite, schist and slate which have a layered or banded appearance that is produced by exposure to heat and directed pressure.

2) **Non-foliated metamorphic rocks** such as marble and quartzite which do not have a layered or banded appearance.

Pictures and brief descriptions of some common types of metamorphic rocks are provided below.



Amphibolite

Amphibolite is a non-foliated metamorphic rock that forms through recrystallization under conditions of high viscosity and directed pressure. It is composed primarily of amphibole and plagioclase, usually with very little quartz.

Gneiss

Gneiss is foliated metamorphic rock that has a banded appearance and is made up of granular mineral grains. It typically contains abundant quartz or feldspar minerals.

Marble

Marble is a non-foliated metamorphic rock that is produced from the metamorpbism of limestone. It is composed primarily of calcium carbonate.

Phyllite

Phyllite is a foliate metamorphic rock that is made up mainly of very fine-grained mica. The surface of phyllite is typically lustrous and sometimes wrinkled. It is intermediate in grade between slate and schist.

Quartzite

Quartzite is a non-foliated metamorphic rock that is produced hy the metamorphism of sandstone. It is composed primarily of quartz.

Schist

Schist is metamorphic rock with well developed foliation. It often contains significant amounts of mica which allow the

rock to split into thin pieces. It is a rock of intermediate metamorphic grade between phyllite and gneiss. The specimen displayed in showcase is a "chlorite schist" because it contains a significant amount of chlorite.

Slate

Slate is a foliated metamorphic rock that is formed through the metamorphism of shale. It is a low grade metamorphic rock that splits into thin pieces.

TOUCH, FEEL AND LEARN EXHIBITS:

This is also known as 'Touch and Feel' corner in the gallery. In view of the changing styles of display of museum objects and also to provide opportunity to experience the touch and feel of rocks, for better understanding, this 'corner' was created in a novel manner.

It is also intended to evince interests in children, especially school students to understand the field of geology.

It is another nobler purpose to enable visually challenged differently abled persons to touch and feel the rocks and develop appreciation and interest in Geology. It is opening a new thinking in the museum to place few objects in open for visitors to touch and understand them better and also have a feeling of touching few objects which otherwise would not have been possible in their life time. This has become a great attraction and a trend setter in developing new museums.

MINERALOGY

Mineralogy is that branch of geologic science which deals with the study of minerals. A mineral is usually a natural inorganic substance having a definite chemical composition and a characteristic atomic structure. Few are powdery or resinous but most are crystals. The minerals are indispensable to man. Moreover minerals are the backbone of our modern industries. More than 300 varieties of minerals and their ores are included in the collection of Madras Museum.

Most sedimentary rocks contain either quartz (especially siliciclastic rocks) or calcite (especially carbonate rocks). In contrast with igneous and metamorphic rocks, a sedimentary rock usually contains very few different major minerals. However, the origin of the minerals in a sedimentary rock is often more complex than those in an igneous rock. Minerals in a sedimentary rock can have formed by precipitation during sedimentation or diagenesis. In the second case, the mineral precipitate can have grown over an older generation of cement.

The gallery has common minerals and ores of minerals displayed in separate showcases. Some of the important minerals and ores are described here.

Apatite

Apatite is a phosphate of calcium with fluorine of choiring. Crystals are common. It is commonly sea-green or bluish-green in colour and produces a white streak. Apatite occurs in crystalline limestones and in igneous and metamorphic rocks. Apatite is used as a fertilizer.

Calcite

Calcite is a carbonate of calcium and it crystallises in the rhompohetral class of the hexagonal system. An interesting feature of this mineral is that the crystals exhibit a great variety of forms. It also occurs in fibrous, stalactitic, nodular, granular, compact and earthy forms, it is a perfect rhompohetral cleavage.

It occurs in a variety of colours and its streak is white to grey. Some calcites exhibit fluorescence and some exhibit phosphorescence on heating.

Calcite is wide spread in occurrence commonly occurring in sedimentary rocks and in the cavities of lavas. Calcite is chiefly used in the manufacture of cement. In Tamil Nadu Calcite occurs in Salem, Tirunelveli and Ramanathapuram districts.

Steatite

Steatite is a high great massive talc. Steatite which is free from cracks and inclusions is used in the manufacture of high frequency insulators in the radio industry and in the manufacture of radar and electronic equipments. It is also used in the manufacture of oil and gas burner types. The most important use of steatite is in the manufacture of special porcelain and refractories.

MINERAL RESEOURCES OF TAMIL NADU

The state of Tamil Nadu is the southern province of the Indian Peninsula. The rich and varied mineral resources of the state have contributed generously towards the development and industrialization of the state. It is one of the leading states in the reserves of the following minerals viz., Lignite, Garnet, Magnesite, Quartz, Feldspar, Clay, Limestone, Bauxite, Graphite and Granite. Geologically, the hilly terrains and the middle level plain contain crystalline hard rocks such as charnockites, granite, gneiss, khondalites, leptynites, metamorphic gneisses with detached occurrences of crystalline limestone, iron ore, quartzo-feldspathic veins and basic intrusive such as dolerites and anorthosites. Coastal zones contain sedimentary limestones, clay, laterites, heavy mineral sands and silica sands. The hill ranges are sporadically capped with laterites and bauxites of residual nature. Gypsum and phosphatic nodules occur as sedimentary veins in rocks of the Cretaceous age. Gypsum of secondary replacement occurs in some of the areas adjoining the foothills of the Western Ghats. Lignite occurs as sedimentary beds of tertiary age.[3]

The followings are the distribution of minerals in the different districts of Tamil Nadu:

- **Heavy mineral sands and Silica Sand:**

The coastal districts of Kanyakumari, Tirunelveli, Tuticorin, Ramanathapuram and Nagapattinam are endowed with high quality mineral placers such as garnet, rutile, leucoxene, monazite and zircon. They have wide use in pigment, refractory, ceramic industries and nuclear industry[4]

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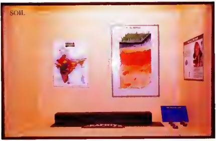
[3] Department of Geology and Mining, Government of Tamil Nadu, Chennai

The reserve of silica sand is about 115 million tones and occurs in parts of coastal areas of Nagapattinam, Cuddalore, Kanchipuram and Tiruvallur districts



- **Graphite:**

Tamil Nadu is having deposits of export quality flaky graphites. It is distributed in sizable quality in Sivaganga, Ramanathapuram, Madurai and Tirunelveli districts. The total reserves of Graphite are about 2 million tonnes.

- **Magnesite:**

One of the world's best magnesite deposit occur in

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[4] Anon, 2000 Indian Minerals Year Book, Ministry of Mines, Government of India

Salem, Namakkal, Coimbatore and Erode districts. The magnesites reserves in Tamil Nadu are about 73million tones. Magnesite is used mainly for refractory purposes and in Chemical industries.

- **Clay:**

Clays of refractory of stoneware and ceramic grades occur extensively in Cuddalore, Pudukkottai, Tirunelveli, Tiruvarur, Kanchipuram and Tirvannamalai districts. The reserves are 9 million tones.

- **Biotite:**

Biotite is a dark coloured mica black to green in colour. In then flakes it is green or brown. Biotite occurs in Igneous and metamorphic rocks.

- **Lignite:**

Tamil Nadu is endowed with the biggest deposits of Lignite in India. The total reserves are 30275 million tones. Neyveli Lignite Corporation (NLC) has lead to development of large industrial complex around Neyveli in Cuddalore district with the thermal power plants, fertilizer, brequetting and carbonization plants. Further investigation in and around Mannargudi, Jayamkondam and Srimushnam areas have revealed that existence of lignite as in Neyveli.

- **Quartz and Feldspar:**

Quartz

It is the commonest mineral widely distributed in all kinds of rocks. It is an oxide of silicon occurring as masses and as hexagonal crystals. Quartz is used in the manufacture of glass, porcelain, refractory, abrasive, paint, lenses and optical instruments. It is also used in the metallurgical and chemical industries. Quartz sand is used in mortar and concrete.

High grade deposits of Quartz and Feldspar occur in Tamilnadu and these are exported to several parts of the world. Their deposits occur in Salem, Madurai, Erode and Dindugal districts.

QUARTZ

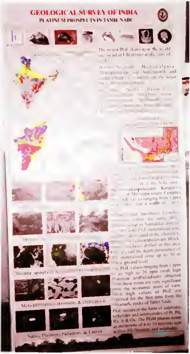
- **Limestone:**

Tamil Nadu ranks seventh in the country in terms of production of limestone. Limestone based cement and chemical industries have been flourishing for the past three decades as cement grade limestone deposits are abundant in the state. They occur in the districts of Perumbalur, Tirunelveli, Tuticorin, Virudhunagar, Salem, Karur, Namakkal, Dindigul, Coimbatore and Madurai.

- **Granite:**

Tamil Nadu has vast resources of granite of different colours and shades. The total reserve of granite is about 710 million cubic meters. Granites are used in building facading, flouring, decorative and ornamental uses and in monuments. Kunnam black of Tindivanam, Paradiso of Dharmapuri, Juhrana of Pudukkottai, Kashmir white of Madurai are popular varieties in the International Market. Black Granite occurs in the districts of Kanchipuram, Vellore, Villupuram, Dharmapuri, Salem and Erode. Other coloured granites occur in Dharmapuri, Pudukkottai, Madurai, Salem and Namakkal districts.

The Geological Survey of India, Kolkata has enriched the Geology Gallery by donating few objects and postures which gives useful information about the Molybdenum and Platinum prospects in Tamil Nadu and about the Seismic hazard micro zonation of Chennai.



GEOLOGICAL SURVEY OF INDIA
PLATINUM PROSPECTS IN TAMIL NADU

The PGE values ranging from 1 ppm as high as 26 ppm (with high Platinum and Palladium) obtained from these zones are very significant from the economic point of view. Such high values of PGE are reported for the first time from the ultramafic rocks of Tamil Nadu.

PGE occurs in the form of sulphides, tellurides and antimonides of Pt, Pd, Ru, Ir & Os. The PGM phases occur as inclusions of 6 to 10 microns size within the chromite and sulphides.

Native Platinum, Palladium & Laurite

ECONOMIC GEOLOGY

The Economic Geology deals with the economic aspects, which is the core of geology. The Economic Geology gallery consist of valuable exhibits of Gold and Silver, various types of ores, refractories, gemstones, building stones, coal, lignite and ceramics. The display and description of these in showcases in the gallery are shown below.

ORES

An ore is a natural combination of minerals from which metals can be extracted at a profit. Originally the term ore was

applied only to metallic minerals, but the term now includes non-metallic substances that have been deposited in rocks after its formation. All metals form ore deposits found in the Earth's crust. Large ore deposits can mean great wealth of a country.

Chromite

Chromite is the chief ore of chromium. It is black or brownish black in colour and produces a brownish streak by which it is distinguished from magnetite and ilmenite.

Magnetite

Magnetite also known as magnetic iron ore is a sesquioxide and protoxide of iron and is an important ore of iron.

It contains about 72 per cent of iron. It crystallises in the cupic system usually as octahedrons and dodecahedrons it is strongly attracted by a magnet. Its colour and streak are black.

Magnetite occurs in basic igneous rocks and metamorphosed, sedimentary rocks. In Tamil Nadu magnetite deposits occur in Salem and Tirchy districts.

Bauxite

Bauxite is a hydrous oxide of aluminium and is the only ore from which aluminium is extracted. It occurs as an amorphous mass and in concretionary grains. It is earthy in appearance. When pure it is in colour. Commonly it is yellow, brown or red or a mixture of these colours.

Bauxite is formed by prolonged weathering of aluminium bearing rocks under tropical climatic conditions.

Malachite

Malachite is a hydrated basic carbonate of copper. It commonly occurs in massive form with a smooth mammillary or botryoital surface. It is commonly banded with different shades of green. Crystals are rare. It is bright green in colour and its streak is pale green.

Malachite is an altered produced of the ores of copper. Hence it is usually found associated with such ores in the oxidized zone and below this usually the sulphide zone of copper occurs. Malachite is used as an ore of copper and as an ornamental stone.

Galena

Galena commonly known as lead glance is a sulphide of lead crystallising in the cubic system. Cubic crystals are common. It is a heavy mineral. Galena has a perfect cupic cleavage. Its colour and streak are lead grey and the lustre is metallic. Galena usually occurs associated with ores of zinc, silver and copper. Galena is the chief ore of lead. It usually contains some amount of silver which is recovered during the extraction of lead. The most important source of Galena in India is from Zawar; in Udaipur; Rajasthan. In Tamil Nadu it occurs associated with ores of zinc and copper in the Mamandur area of Sourth Arcot district.

Chalcopyrite

Chalcopyrite is copper pyrites, is a sulphide of copper and iron crystallising in the tetragonal system. It commonly occurs in massive form. It is brass yellow in colour and its streak is greenish black. Chalcopyrite is distinguished from pyrite by its yellow hardness and brass yellow colour which is somewhat darker than pyrite.

Chalcopyrite is the chief ore from which copper is extracted. It occurs in igneous and metamorphic rocks. In India, chalcopyrite is being mined in the Singhphum district of Bihar.

Few gem stones which are attractive are displayed in the gallery.

PALAEONTOLOGY

The term 'Palaeontology' is a science which deals with the study of fossils. The fossils are the recognizable remains of animals and plants which lived in the past geological ages and preserved in the rocks of the earth crust by natural process.

Sedimentary rocks are the only type of rock that can contain fossils, the remains or imprints of dead organisms. In nature, dead organisms are usually quickly removed by scavengers, bacteria, rotting and erosion. In some exceptional circumstances a carcass is fossilized because these natural processes are unable to work. The chance of fossilization is higher when the sedimentation rate is high (so that a carcass is quickly buried), in anoxic environments (where little bacterial activity exists) or when the organism had a particularly hard skeleton. Larger, well-preserved fossils are relatively rare.

Fossils can both be the direct remains or imprints of organisms and their skeletons. Most commonly preserved are the harder parts of organisms such as bones, shells, woody tissue of plants. Soft tissue has a much smaller chance of being preserved and fossilized and soft tissue of animals older than 40 million years is very rare. Imprints of organisms made while still alive are called trace fossils. Examples are burrows, foot prints, etc.

The various types of fossil exhibits in this museum are the collections from Ariyalur, Tricby district of Tamil Nadu.

Giant Ammonite Fossil

The huge fossil wood from Tiruvakkarai is also exhibited in the Museum garden. The Giant Ammonite fossil, *Pachydiscus peramptus* is from Ariyalur. It belongs to the Cretaceous period. It contains complicated types of suture line. Its size is 2 feet – diameter.

Ammonites are the most widely known fossil; they are cephalopods and first appeared in the seas 415 million years ago. Ammonite fossils are found on every continent. Because of their rapid evolution and wide spread distribution they are an excellent tool for indexing and dating rocks. The occurrence of fossils constitutes an integral part for the discovery of new deposit of coal and petroleum.

Being part of a sedimentary rock, fossils undergo the same diagenetic processes as the rock. A shell consisting of calcite can for example dissolve, while a cement of silica then fills the cavity. In the same way, precipitating minerals can fill cavities formerly occupied by blood vessels, vascular tissue or other soft tissues. This preserves the form of the organism but changes the chemical composition, a process called permineralisation. The most common minerals in permineralisation cements are carbonates (especially calcite), forms of amorphous silica(chalcedony, flint, chert) and pyrite. In the case of silica cements, the process is called lithification.

At high pressure and temperature, the organic material of a dead organism undergoes chemical reactions in which volatiles like water and carbon dioxide are expulsed. The fossil, in the end, consists of a thin layer of pure carbon or its mineralized form, graphite. This form of fossilisation is called carbonisation. It is particularly important for plant fossils. The same process is responsible for the formation of fossil fuels like lignite or coal.

COAL

Coal is a rock that is a source of energy. Coal is a very important fuel; it has been formed by the accumulation of large quantities of vegetation in shallow waters in the geological past which were subsequently covered by beds of mud, sand and other sediments. Due to the heat and pressure produced by the deposition of sediments the vegetable matters was gradually carbonized. Depending upon the nature of the sediments various types of coal were formed. Peat, lignite or brown coal, bituminous coal and anthracite are the important varieties of coal.

In the gallery there are beautiful diorama showcases of Carboniferous forest, Geological time scale, Grand Canyon etc which provides useful information to the visitors especially to the children.

CARBONIFEROUS FOREST

GRAND CANYON

Apart from these, the other rare objects displayed in the geology gallery are model of an extinct reptile, brontosaurus. This model is 1/25· the size of the original reconstruction in United States of America, of this particular reptile which is ranked as one among the largest animals that ever roamed on the earth. Rhinoceros skull-Fossil, trilobites, archaeopteryx, triceratops model, pictures of wooly mammoth etc. are interesting to see. The evolution and extinction of dinosaurs is depicted by pictures with descriptive labels and with a big painting in the mezzanine floor of the gallery.

Fossils have practical value hecause they change throughout the rock column. The exact mix of fossils serves to identify and correlate rock units in widely separated places,

Brontosaurus

Rhinoceros skull-Fossil

even in the grit pumped up from drill holes. The geologic time scale is based almost entirely on fossils supplemented with other dating methods. With it we can confidently compare sedimentary rocks occurring everywhere in the world. Fossils are also resources, valuable as museum attractions and as collectibles, and their commerce is increasingly regulated.

A view of Mezzanine Gallery

CONCLUSION

Earth history is the intricate story of minerals, rocks, fossils, landforms and tectonics. Fossil studies, in combination with gene-based techniques, yield a consistent evolutionary history of life on Earth. The Phanerozoic Eon (age of fossils) of the last 550 million years is well mapped as a time of expanding life punctuated by mass extinctions. The previous 4 billion years—Precambrian time—being revealed as an age of enormous changes in the atmosphere, oceans and continents.

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ANNEXURE - 1

GEOLOGICAL TIME SCALE

The Earth is 4,600 million years. This huge span of time is difficult to imagine, so events in the earth's history are therefore measured in Geological time spans of millions of years. Geologists divide time into Eons, which comprises Eras and which is subdivided into periods.

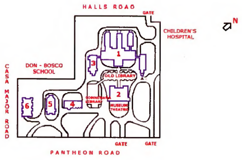
ANNEXURE – 2

ROCKS AND MINERALS TODAY

Rocks and minerals are found all over the world. We use them in our everyday lives without even realising it. Here is a list of some of the more unusual rocks and minerals and their uses.

Product	How it is extracted	What it is used for
SALT	Solution mining is used to extract deposits underground Sea water may be evaporated.	Salt is added to food to preserve it or to enhance taste. It consists of sodium and chlorine.
QUARTZ	Quartz may be mined from granite rocks or extracted from sand or gravel.	It is used in watches and optical instruments. It is a source of silica, which is used to make silicon chips
GRAPHITE	Graphite is mined from rocks such as gneiss and schist.	It is used as 'lead' in pencils, as a lubricant, in paint and to make parts for electric motors
BORAX	Borax is obtained from the beds of dry salt lakes or by evaporating Sea water.	It is used in bleaches, soaps and detergents. It is also added to ceramics and fertilisers
PHOSPHATE	Phosphate comes from phosphate rock, which is mined. Sea bird droppings also contain it.	It is used in match heads and in some medicines. But its main use is in fertilisers.
TITANIUM	Minerals containing it are minted and it is extracted in a protected atmosphere.	Titanium is used to make pigment for paints. It is a light, strong metal used in jet engines.
PLATINUM	Platinum is extracted from some metal ores. It must be smelted and refined.	It is used to make jewellery and wires. It is used in dentistry, in jet engines and to coat missile nose cones.
SULPHUR	Sulphur is mined by being melted with hot steam. It is also extracted from some metal ores.	Its main use is the manufacture of sulphuric acid for industrial uses such as making fertiliser.
FLUORITE	Fluorite is found in mines in its pure, crystal form. Other minerals such as quartz can be found attached to it.	It is quite a soft gem and is therefore mainly used to make jewellery such as earrings. as earrings.

ANNEXURE – 3



SITE PLAN
GOVERNMENT MUSEUM
CHENNAI - 600 008.

Government Museum, Chennai.

Pantheon Road, Egmore, Chennai - 600 008
Phone - +91- 44 28193238 Fax - +91- 44 28193035
website - www.chennaimuseum.org email - govtmuse@tn.gov.in

Established in 1851, this multi-purpose Museum is located in 16.25 acres of land with six independent buildings housing 46 Galleries.
❶ Main Building, ❷ Front Building, ❸ Bronze Gallery, ❹ Children's Museum, ❺ National Art Gallery ❻ Contemporary Art Gallery

Museum is open on all days, from 9.30 A.M. to 5.00 P.M., except on FRIDAYS and NATIONAL HOLIDAYS (26th January, 15th August and 2nd October)

General Information

Location : Pantheon Road,
Egmore,
Chennai - 600 008.
Tamil Nadu India.

Accessibility : 1/2 KM from the Egmore Railway Station. 2 KM from the Central Railway Statior
20 KM from Meenambakkam Air Port.

Working Hours : 9.30 a.m. to 5 p.m.

Holidays : Fridays and National Holidays viz. Republic Day (26th January),